ARPA Network Information Center
Stanford Research Institute
Menlo Park, California 94025

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Packet Radio Temporary Note # 22

Ward F. Hardman (SRI)
5-FEB-73

PACKET RADIO COMMUNICATIONS REQUIREMENTS OF A TYPICAL FIELD ARMY

The objective of this note is to set forth representative tactical communications requirements that might be satisfied by a packet radio system. These requirements are those of a typical military force deployed in an active conflict situation. The force model addressed in this note is a field army consisting of two corps, each with four divisions. The conflict situation chosen is similar to mid-intensity warfare in Europe, in which conventional weapons are being used but the possibility of the use of tactical nuclear weapons is present and reflected in troop dispositions. In order to simplify the initial system design of a military tactical packet radio system, only ground-to-ground communications requirements are stated. Air-to-air and air-to-ground communications can be addressed later when the system design has progressed to the point that the problem of long range line-of-sight (LOS) of airborne transceivers capable of accessing numerous packet radio repeaters and stations is being analyzed.

There are two primary ground-to-ground communications systems used by the field army:

(1) The nodal multichannel Army Area Communications System (AACOMS), which extends from the field army rear boundary forward to brigade command posts (CPs) in the brigade rear area. AACOMS is comprised of a gridded area communications system providing essentially common user service through a number of area communications centers, and several command communications systems following the chain of command that provide

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(1) The nodal multichannel Army Area Communications System (AACOMS) which extends from the field army rear boundary forward to brigade command posts (CPs) in the brigade rear area. AACOMS is comprised of a gridded area communications system providing essentially common user service through a number of area communications centers, and several command communications systems following the chain of command that provide

sole-user channels and some common-user service. The developmental TRITAC digital automatic switches will serve the nodes of the AACOMS network. The multichannel system carries voice, teletype, data (high and low speeds), and facsimile traffic.

(2) Tactical radio nets, which provide the bulk of the communications within the front-line divisions, particularly in the maneuver brigade and battalion areas. Voice radio communications predominate, but voice radio nets also carry some data traffic. Tactical radio nets, normally those operating in the HF frequency band, are used for teletype traffic as well.

Figure 1 depicts a typical Army theater of operations and Figure 2 shows a division area. The rear and flank boundaries between units of different echelons are indicated by the following symbols:

0000 - Theater
XXXX - Field Army
XXX - Corps
XX - Division
X - Brigade
|| - Battalion

The dimensions of the various areas will frequently differ from the typical dimensions shown on these figures because of geography, terrain, and the opposing forces strength and disposition. The division is shown in a defensive posture.

Table I shows the approximate sizes of the areas of operations of the various echelons of the Army in the Field. The corps front with two divisions in the line would be about 100 km, while with three divisions in the line, it would be about 150 km. The field army front could vary between 200 and 300 km.

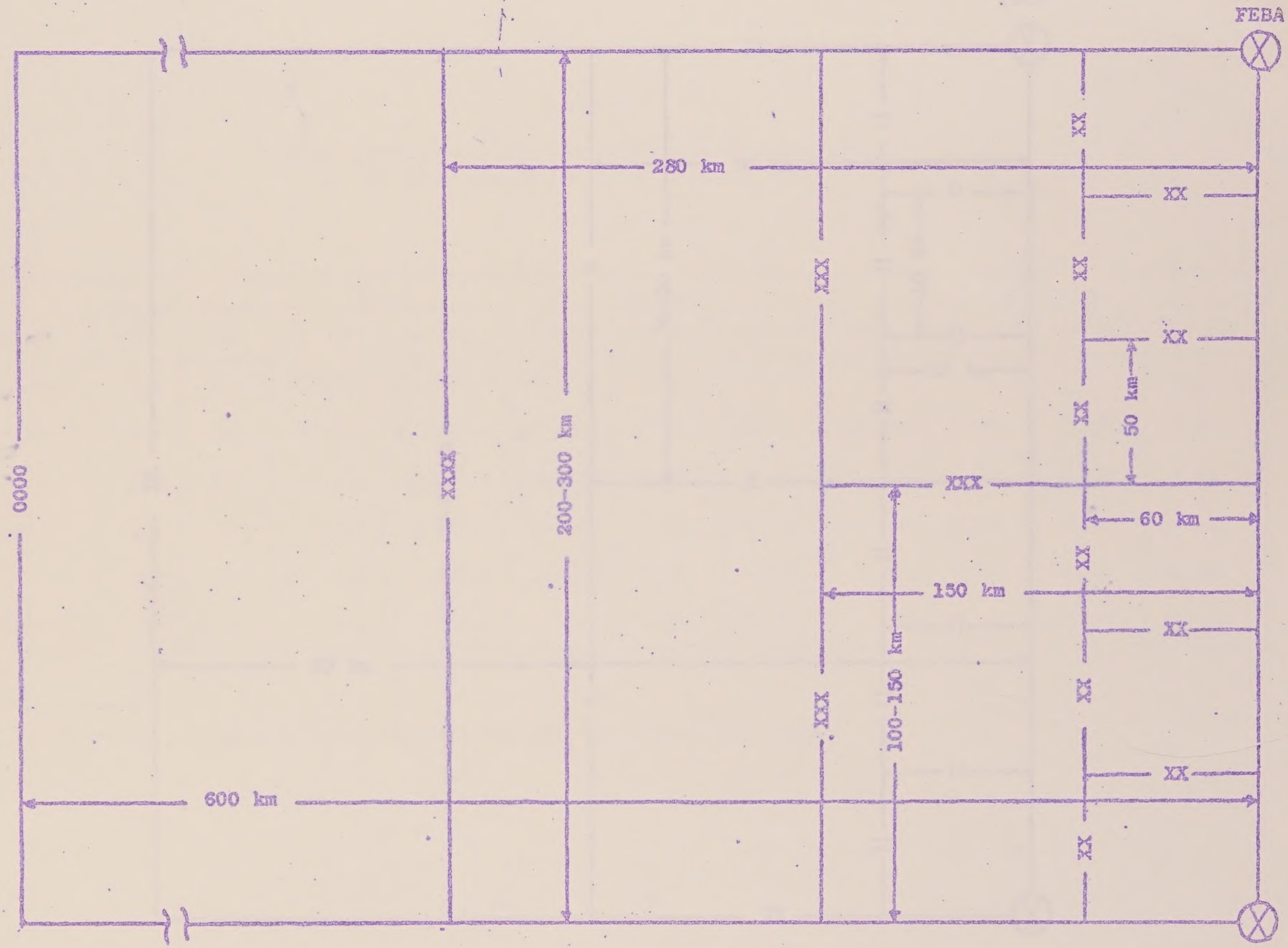
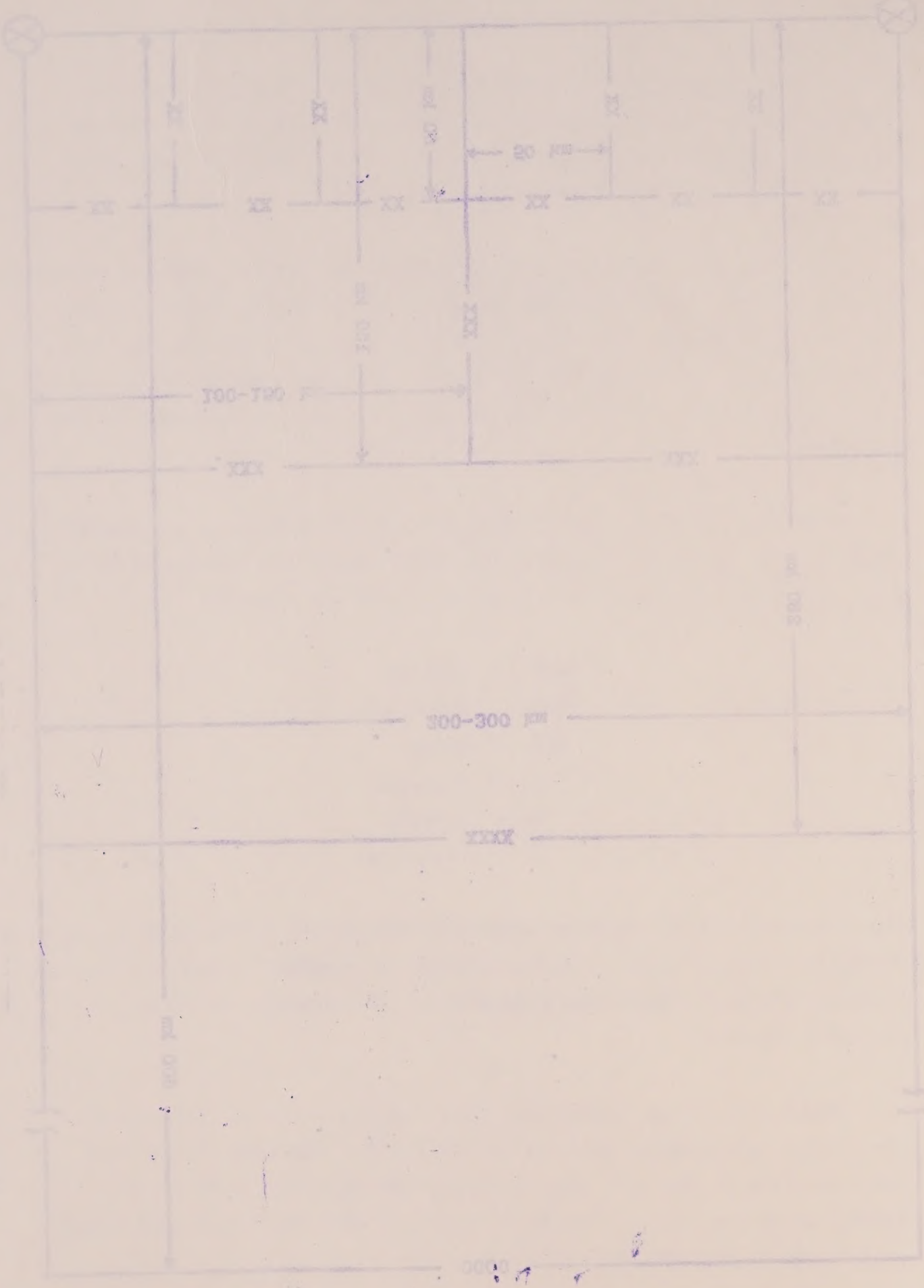


Figure 1. Theater Area of Operations



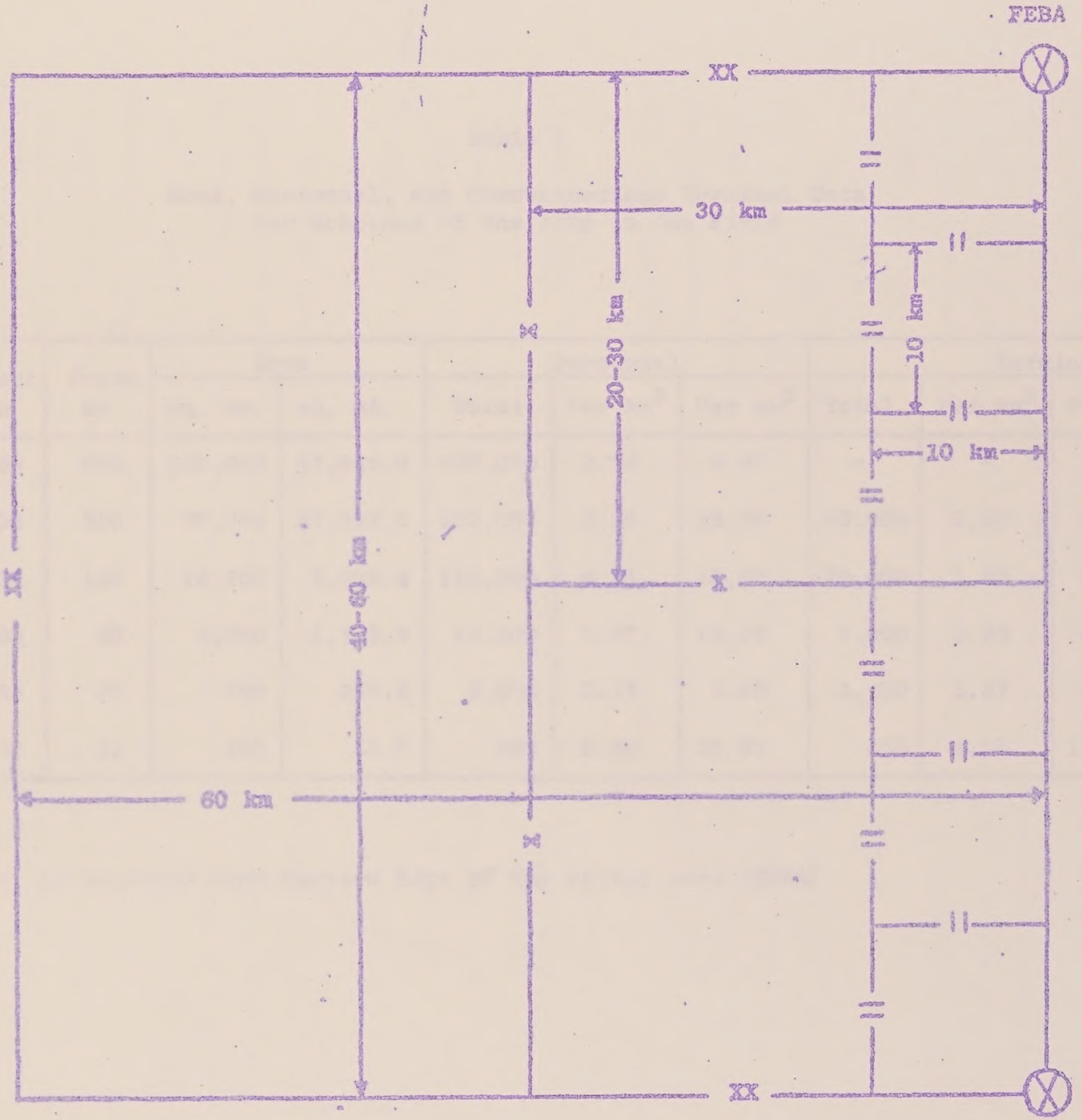


Figure 2. Division Area

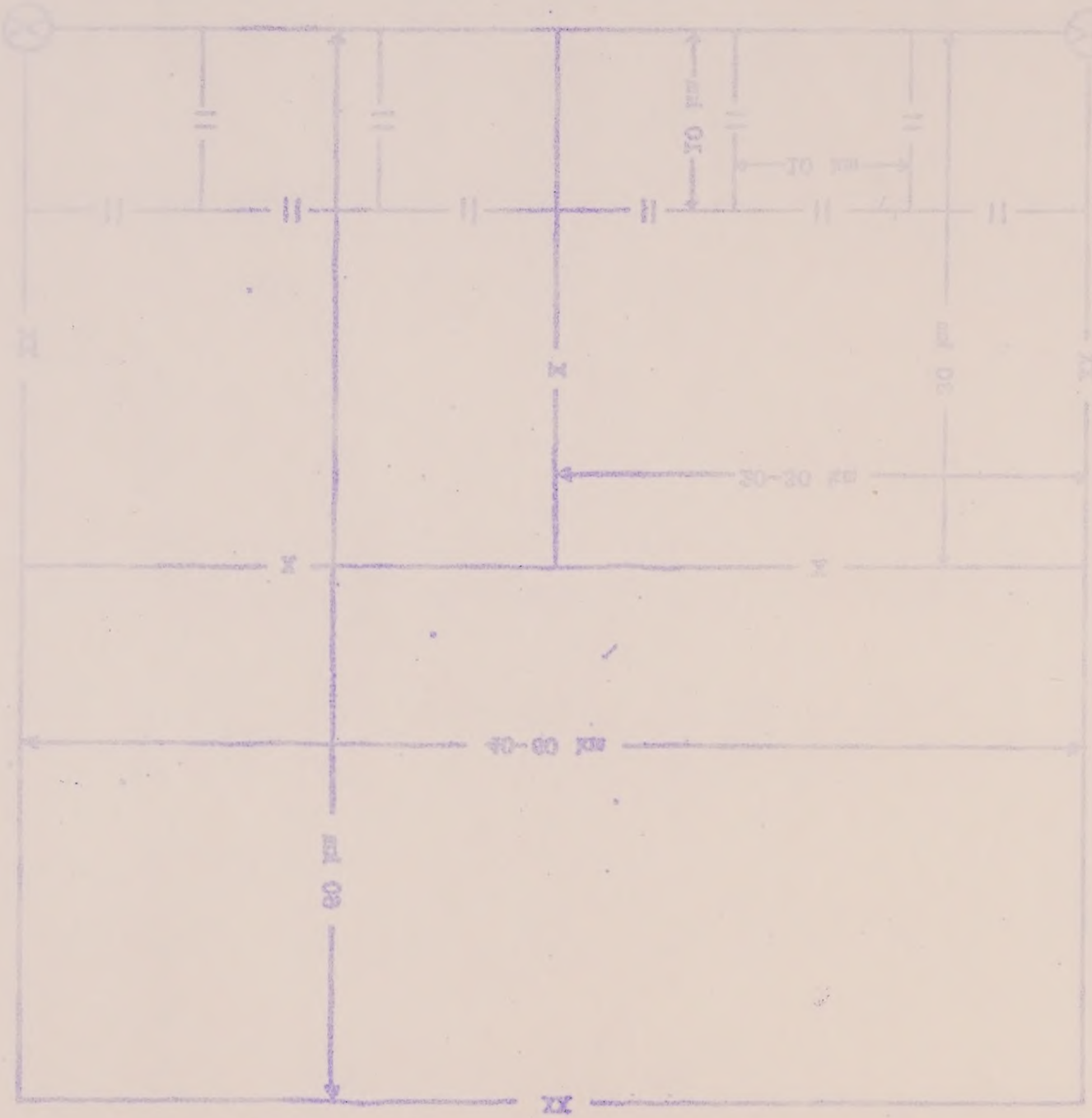

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Table I

Area, Personnel, and Communications Terminal Data
for Echelons of the Army in the Field

Echelon	Front km	Depth km	Area		Personnel			Terminals			
			sq. km.	sq. mi.	Total	Per km^2	Per mi^2	Total	Per km^2	Per mi^2	Per man
Theater Army	250	600	150,000	57,915.0	560,000	3.73	9.67	-	-	-	-
Field Army	250	280	70,000	27,027.0	360,000	5.14	13.32	63,000	0.90	2.33	0.18
Corps	125	150	18,750	7,239.4	115,000	6.13	15.89	29,000	1.55	4.01	0.25
Division	30	80	3,000	1,158.3	17,000	5.67	14.68	7,000	2.33	6.04	0.41
Brigade	25	30	750	289.6	2,600	3.47	8.98	1,400	1.87	4.83	0.54
Battalion	10	10	100	38.6	920	9.20	23.83	450	4.50	11.66	0.49

Note: Depth in km. is measured from Forward Edge of the Battle Area (FEBA)

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Table I also shows the approximate numbers of personnel and communications terminals in the areas of operations of various combat formations from battalion through field army. The Table I shows only the typical size and number of personnel for the theater army area, which includes the area behind the army rear boundary referred to as the communications zone (COMMZ). The number of communications terminals in the COMMZ is difficult to estimate, and is not shown in Table I, because forces and installations of all of the military services may be located therein.

The design of any communications system serving the field army must provide for continuity of communications among forces that are highly mobile. Specifically, the system must be able to accommodate frequent displacement of command posts, for which the following criteria have been established for divisional elements:

Command Post	Set-up/Tear-down Times	Movement Frequency
Division	30 minutes	1-3 times per day
Brigade	15 minutes	3-8 times per day
Battalions	5 minutes	Every 3-4 hours
Company	0 minutes	Every 1-3 hours

Table II shows the estimated ground-to-ground communications requirements of the typical field army consisting of 2 corps, each with four divisions, deployed in the areas of operations depicted in Figures 1 and 2. These requirements are tabulated in a format based on the one suggested by Lawrence G. Roberts at the Packet Radio Meeting of December 12-13, 1972. Table II considers the communications traffic offered both to the estimated 128 nodes of the SACCOMS system[1] and to the approximately 5200 ground-to-ground tactical radio nets in this typical field army.[2]

The following explanations apply to the entries in the columns of Table II:

TABLE II

ESTIMATED FIELD ARMY PACKET RADIO COMMUNICATION REQUIREMENTS (GROUND-TO-GROUND)

TYPICAL EQUIPMENT	NO. OF TERMINALS	PEAK HOUR TRAFFIC	AVERAGE MESSAGE LENGTH	PACKET SIZE (BITS)	SYSTEM INFORMATION TRANSFER RATE (KBPS)	TERMINAL INFORMATION TRANSFER RATE (BPS)	INFORMATION GENERATION RATE		PROBABILITY TERMINAL TRANSMITTING
							ALL USERS (P/S)	AVERAGE USER (P/S)	
VOICE TERMINALS	60,000	(CALL-MINUTES) 162,000	1.75 MIN	960*	2,430.0*	3,600	6,750*	0.1125*	0.045
TELETYPE TERMINALS	1,270	(GROUPS) 351,000	150 GP	96	6.435	110	97.5	0.077	0.048
DATA TERMINALS (LOW SPEED)	801	(KBITS) 556,160	16 KBITS	1,200	167.0	2,400	130.6	0.131	0.109
DATA TERMINALS (HIGH SPEEDS)	80	(KBITS) 2,534,000	16 KBITS	1,200	2,371.2	38,400	1,976.8	24.708	0.772
FACSIMILE	49	(PAGES) 265	1 PAGE	1,200	127.2	4,800	78.8	1.722	0.576
SENSOR CONTROL MODULES	1,000								
POSITION LOCATION	12,000								

* VOICE COMPRESSION FACTOR = 0.36. COMPRESSED VOICE INFORMATION RATE IS 900 BPS (2.5 PACKETS OF 360 BITS).

1. Typical Equipment.

a. Voice Terminals. Desk telephones, field telephones, and voice radio transceivers are included.

b. Teletype Terminals. Includes teletypewriters served by AACOMS circuits and by tactical radio teletype nets.

c. Data Terminals. Low speed data terminals may be used on either AACOMS circuits or tactical radio nets. High speed data is transmitted only on AACOMS circuits.

d. Facsimile. All of the facsimile terminals shown in the table are served by AACOMS.

e. Sensor Control Modules. These are radio transceivers or transmitters that relay sensor field data. Each one can serve a sensor field with up to 150 unattended ground sensors. The characteristics of this sensor traffic have not yet been identified, and might have to be extrapolated from fragmentary test and evaluation data. The number of sensor control modules shown in column 3 are reasonable for the typical field army being considered.

f. Position Location. Military position location systems are in early stages of development. The number of position location terminals shown in column 3 as being required for our typical field army were developed by the author of this note in an earlier SRI study.[3] In a passive position location system, these position location equipments would themselves transmit no signals. The characteristics and volume of packet radio traffic that would be generated if accurately located repeaters can be elements of a position location system remains to be determined.

2. Number of Terminals.

a. The numbers of voice, teletype and low speed data terminals represent the totals of each terminal type served by both multichannel and net radio systems. The number of AACOMS telephone users has been reduced by one-eighth to reduce the probability of a user being allocated two packet radios. If we exclude the position location terminals, the field army will require a total of 63,797 packet radios.

b. The data terminals listed should serve the needs of large and small computers, displays, and printers.

3. Peak Hour Traffic.

Peak hour AACOMS traffic is considered to be 1/8 of the total daily traffic. Peak hour tactical net radio traffic is representative of that generated by a unit during a period of heavy operational activity. Peak hour traffic is stated in the following units in Table II:

Voice	-	Call minutes
Teletype	-	Groups of 6 characters
Data	-	Kilobits
Facsimile	-	Pages (8½ inches x 11 inches)

4. Average Message Length.

a. Average message lengths conform to Project MILLARD standards, except for voice messages. The MALLARD standard voice message was assumed to be three minutes in length. Tactical net radio messages are assumed to average 30 seconds in length. Combining the AACOMS and tactical net radio traffic results in an average voice message length of 1.75 minutes for the field army.

b. One facsimile page is assumed to take 6 minutes to transmit, at 96 lines per inch and 800 elements (1600 bits) per line.*

5. Terminal Information Transfer Rates (Bits Per Second).

a. Voice. An assumption is made that digitized voice (uncompressed) at 3600 bps will provide adequate intelligibility and recognizability.

b. Teletype. Use of the 8-level ASCII code requiring 11 bits per character in transmission is assumed. Transmission of 100 words per minute is accomplished at 110 bps.

c. Data. The high speed data rate (38.4 kbps) and low speed data rates (2.4 kbps) correspond to BALLARD standards.

d. Facsimile. Transmittal of one 8½ inch by 11 inch page in 6 minutes requires transmission at 4800 bps.

6. Packet Size (Bits).

The packet size is bits represent arbitrary assumptions, and include only the information that is being transferred, without any "overhead" bits for packet addressal or identification. It corresponds to the text of a written message. In the case of the packet size for teletype messages, 66 bits represents one word or group (5 characters, or 5 characters and a space). The facsimile packet of 1500 bits represents one line.

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* Digital data compression facsimile equipment can reduce this transmission time to one minute. For the finer detail required for the transmission of military maps, diagrams, drawings and printed material, the number of lines per inch can be doubled, resulting in two minutes transmission time.

7. System Information Transfer Rate (kbps).

These figures represent the average total traffic of a specific type that is being offered to the system every second of time during the peak hour. The following are the computations for the voice traffic, assuming a voice compression factor of 0.25:

Call minutes per peak hour = 162,000

Call seconds per second = $\frac{162,000 \times 60}{60 \times 60}$ = 2700 (Erlangs)

System information transfer rate = 2700 x 3600 x 0.25 = 2,430,000 bps

The total average system information transfer rate for all types of traffic during the peak hour is 5,032,535 bps.

8. Information Generation Rate, All Users (Packets Per Second).

These figures show the number of packets per second of a specific type of traffic that is being generated by all of the system users combined during the peak hour. This is equal to the number of packets per second represented by the system information transfer rate. For voice traffic, this is calculated as follows:

Voice packet size = 360 bits

Information generation rate, all users = $\frac{2,430,000}{360}$ = 6750 p/s

9. Information Generation Rate, Average Users (Packets Per Second).

These figures represent the average traffic of a specific type that is offered to the system by a system user during the peak hour. This is equal to the total information generation rate in packets per second of all users divided by the number of users. For voice traffic the calculation follows:

Information generation rate, average user $= \frac{6750}{60000} = 0.1125$ p/s

Note that the listening party on a two party telephone call is not generating information while listening only.

10. Probability Terminal Transmitting.

These figures represent the probability that any single terminal is transmitting traffic of a specific type during a given second during the peak hour. For voice traffic, this is calculated as follows:

No. of calls during average second of peak hour = 2700

Probability terminal is transmitting $= \frac{2700}{60000} = 0.045$

References

1. Luther C. Abel and Horst E. Ulfers, "Processing of User Requirement Data for Mallard Traffic Simulation/Technique Study #43," Research and Development Technical Report ECOM-2886, U.S. Army Electronics Command, Ft. Monmouth, N.J.; October 1967.

2. W. F. Hardman et al, "Tactical Radio Communication System Concept Study, Volume 2: Task A-Definitization of User's Communication Needs (U)," Draft Final Report, U.S. Army Electronics Command Research and Development Technical Report ECOM-0067, Stanford Research Institute, Menlo Park, California; August 1972; SECRET.

3. W. F. Hardman et al, "Analysis of Missions and Navigation Requirements," Stanford Research Institute, Menlo Park, California; November, 1967.

4. Robert S. Meltzer and William V. Taylor, "Digital-fax, Its Significance to the Military," SIGNAL Magazine, January/February, 1973.